

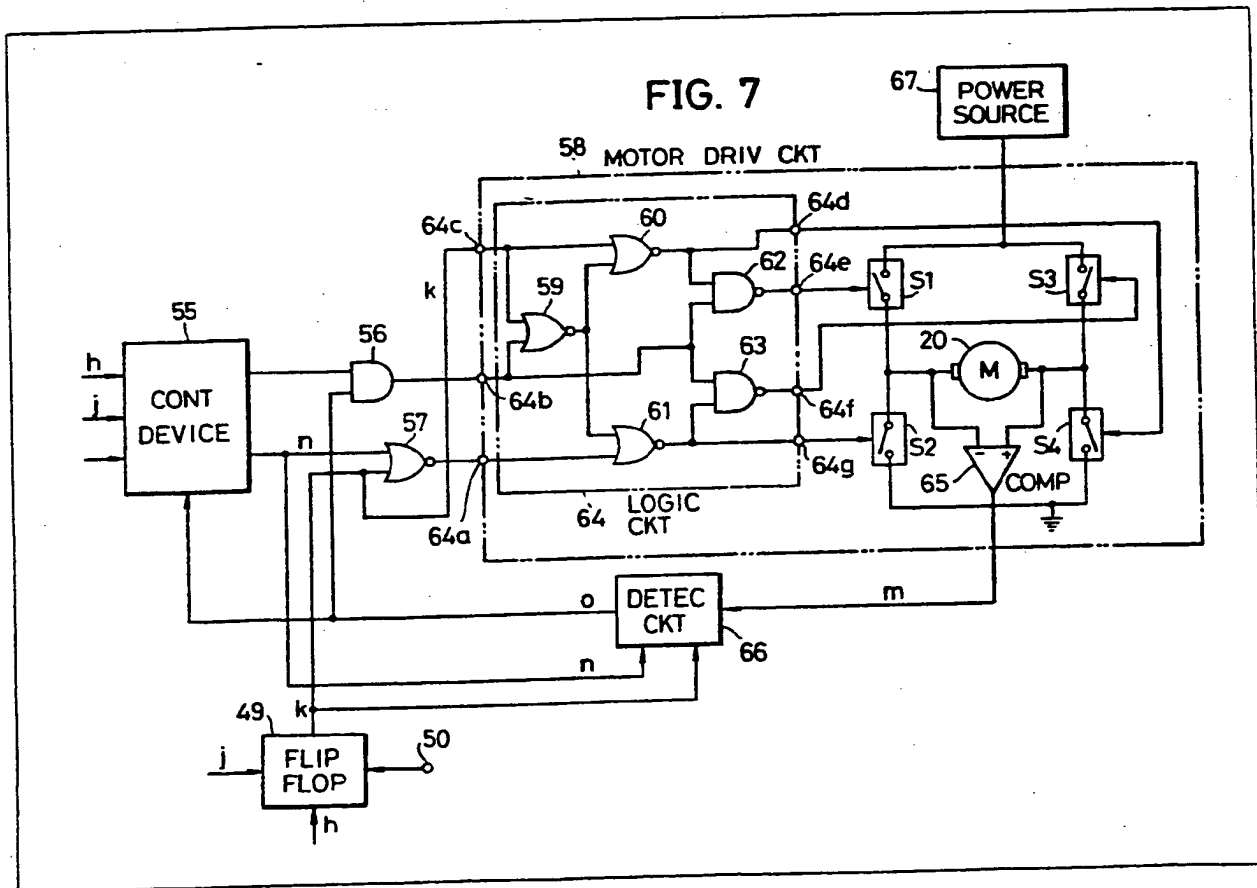
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(54) Apparatus for stopping rotation of a motor

(57) An apparatus for stopping rotation of a motor 20 comprises a power source 67 for supplying a driving voltage to a motor, a reverse voltage applying circuit 58 for alternately applying a reverse voltage to the motor and interrupting the application of the reverse voltage, by applying the reverse voltage to the motor during a first predetermined interval upon stopping the rotation of the motor, and

interrupting the application of the reverse voltage to the motor during a second predetermined interval which follows the first predetermined interval is to chop the reverse voltage, and a detection circuit 66 for detecting the rotation of the motor, eg by means of its back EMF, during the intervals in which the application of the reverse voltage to the motor is interrupted by the reverse voltage applying circuit, to stop the reverse voltage applying operation of the reverse voltage applying circuit when it is detected that the rotation of the motor has stopped.



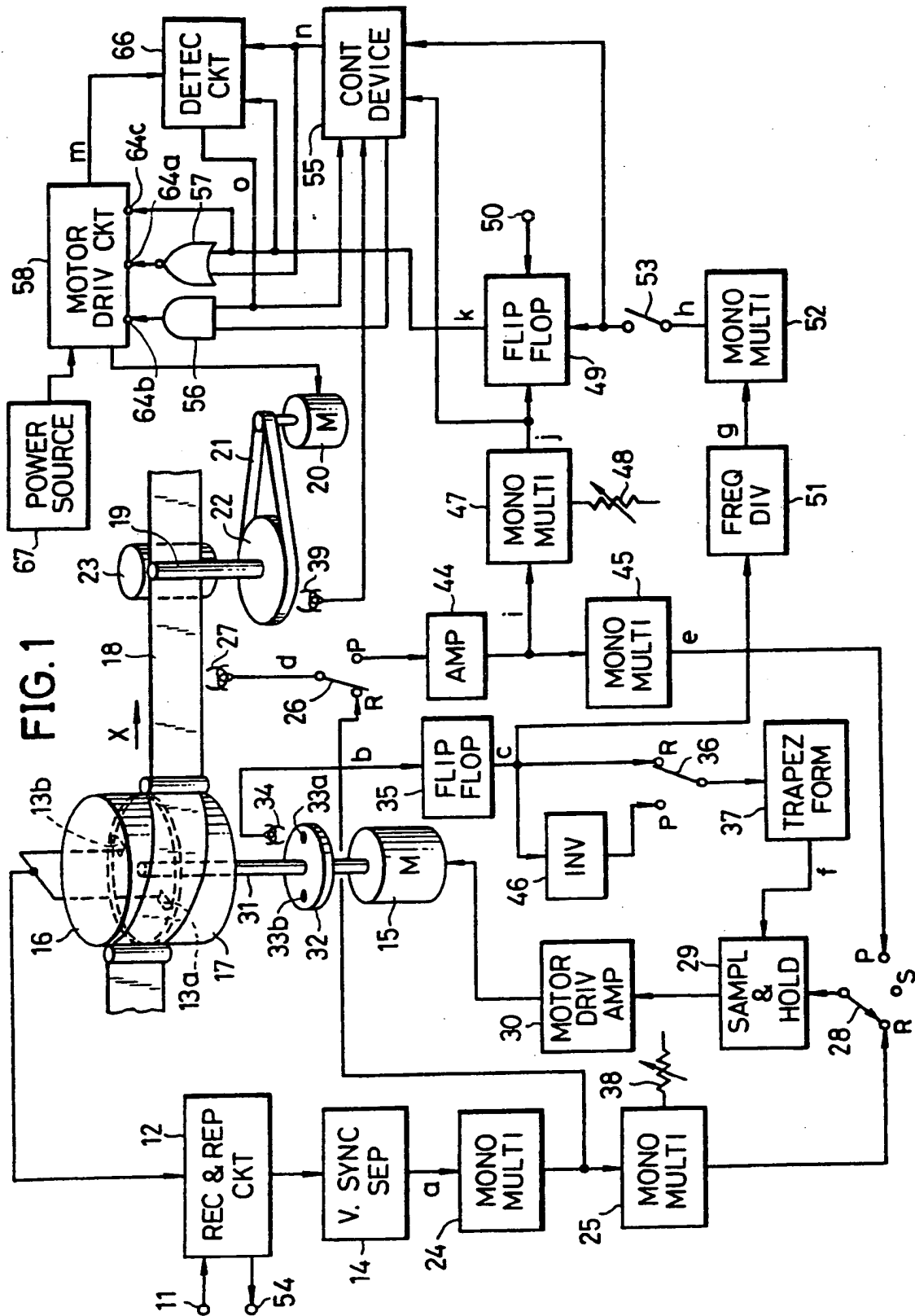


FIG. 4

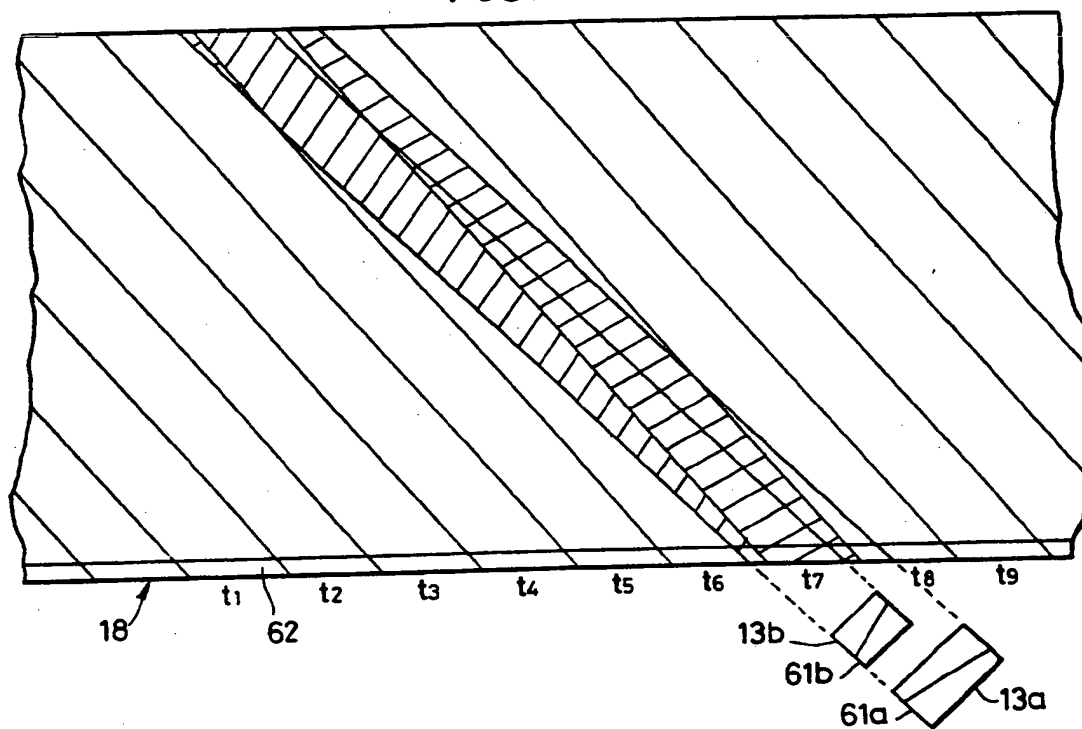


FIG. 5

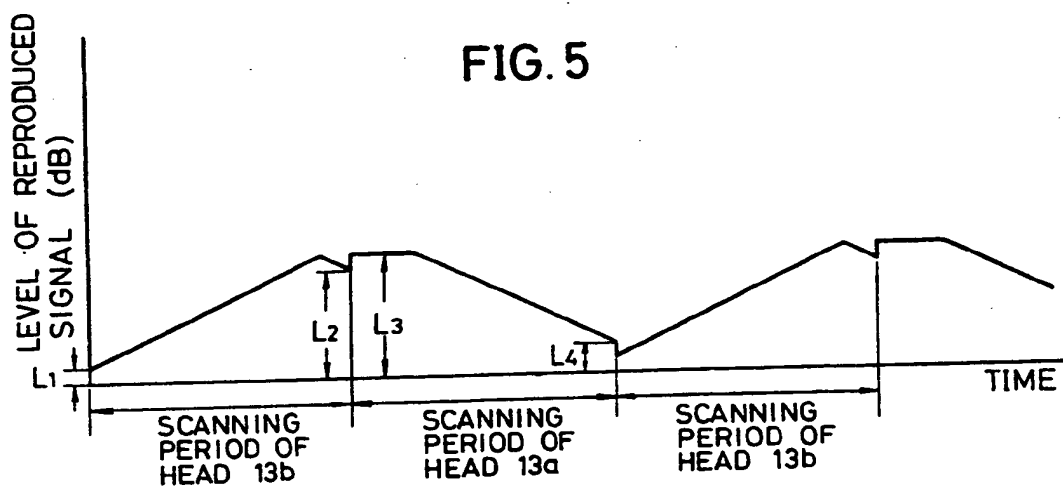


FIG. 6

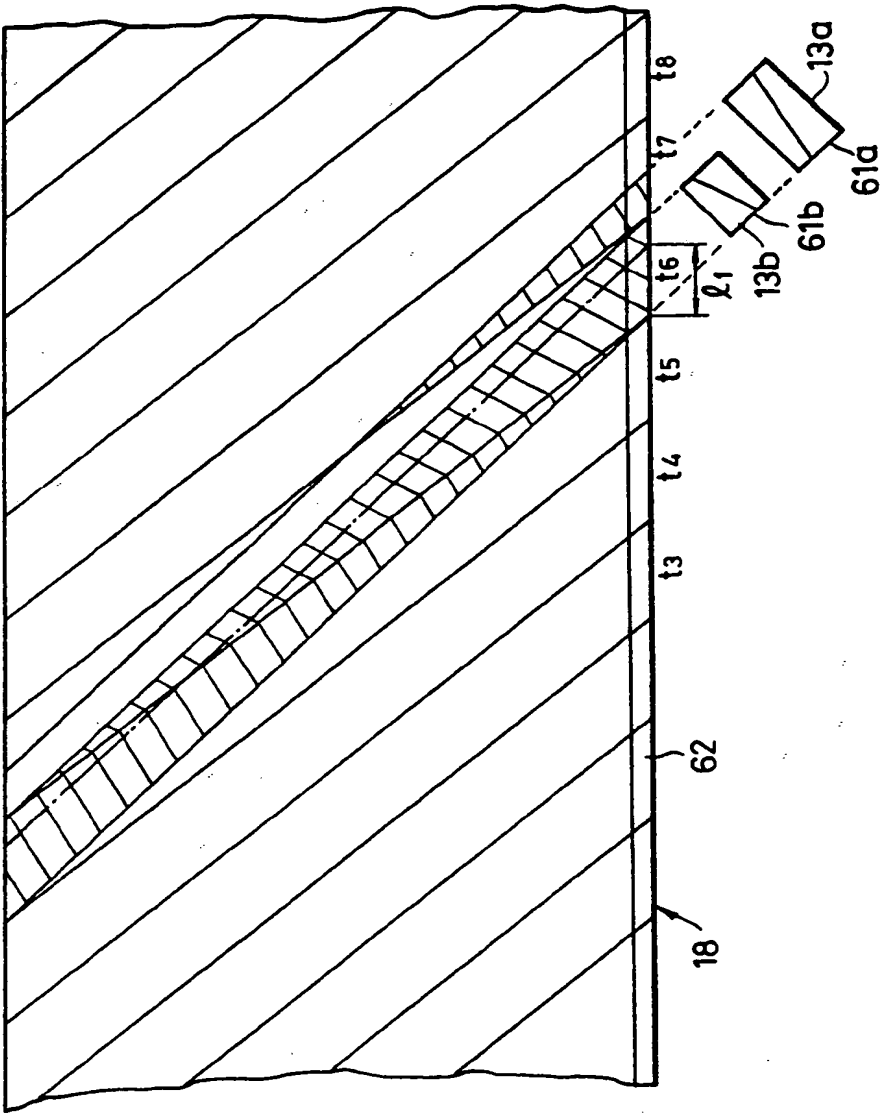
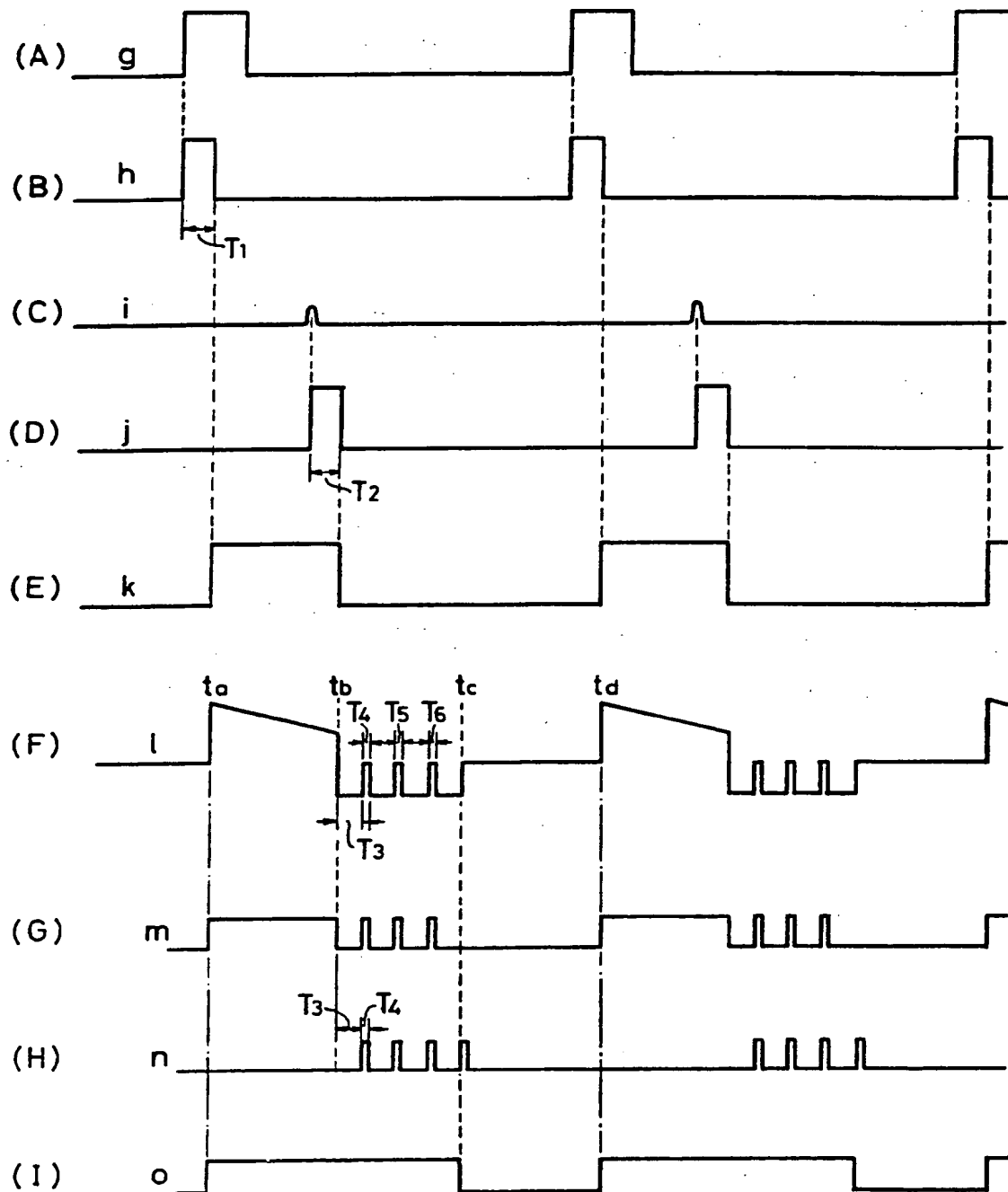


FIG. 8



SPECIFICATION

Apparatus for stopping rotation of a motor

- 5 The present invention generally relates to apparatuses for rapidly stopping rotation of a motor, and more particularly to an apparatus for stopping rotation of a motor which is suitable when applied to a capstan motor in an apparatus which intermittently moves and stops a magnetic tape to perform a slow-motion reproduction by reproducing a video signal recorded in the magnetic tape. 5
- 10 Conventionally, slow-motion picture reproduction were performed by reducing the tape moving speed into a tape moving speed slower than that upon normal reproduction. However, it was difficult to obtain an arbitrary slow-motion reproduced picture having low noise, at an arbitrary slow-motion speed. There was a disadvantage in that noise is inevitably introduced in the reproduced picture. 10
- 15 Accordingly, in order to eliminate the above described disadvantage, a system capable of obtaining a reproduced picture having low noise was proposed in a British Patent Application No. 7926319 in which the applicant is the same as that of the present application. In this proposed system, the magnetic tape is moved intermittently and stopped, and the stopping positions of rotary heads are set so that the rotary head stops at a position on the magnetic tape where the rotary head can scan a track on the magnetic tape in a state in which introduced noise is minimum. 15
- 20 This proposed reproducing system comprises a tape on which video signals are recorded along video tracks, which extend obliquely to the longitudinal direction of the tape with substantially no space therebetween. A control signal is recorded along a control track extending in the longitudinal direction, the video tracks being recorded by a plurality of rotating video heads having gaps of mutually different azimuth angles. The control signal is recorded along the control track interrelatedly with the recording of the video tracks by the video heads. A motor drives the tape in tape travel or stops the tape. A plurality of rotating, reproducing video heads successively trace the video tracks to pick up and reproduce the recorded video signals. The rotating video heads have gaps which have mutually different azimuth angles that are respectively the same as the first mentioned azimuth angles, and which have different height positions above the plane of rotation of the centers of the tracks in the width direction thereof. The control signals are reproduced from the control track of the traveling tape. A circuit delays the reproduced control signal by a specific time to obtain a delayed signal and uses this delayed signal to stop the motor and therefore the tape travel. The tape is stopped at a position relative to the reproducing video heads at which the reproduction is accomplished so that the time instant when the level of the reproduced video signal becomes a minimum is within or in the vicinity of the vertical blanking period. 20
- 25 In the above proposed system, it is necessary to rapidly stop the rotation of the capstan motor, upon stopping of the magnetic tape. 25
- 30 The technique to rapidly stop the rotation of a motor is required in various technical fields, and is not limited to the application in the above described video signal reproducing system. Conventionally, as a general method for stopping the rotation of a motor, there are known methods such as: ① a mechanical stopping method which uses a mechanical brake and the like, and ② an electrical method which obtains stopping torque by short-circuiting the motor terminals, a method which applies reverse torque to the motor by applying a reverse voltage, and the like. However, in the above mechanical stopping method, a braking mechanism which is a separate system, becomes necessary, and there was a limit in reducing the size of the reproducing apparatus. Accordingly, when the above braking mechanism is used frequently, degradation is introduced in the reliability of the system due to break down of the system and the like. On the other hand, in the above electrical stopping method, sufficient stopping torque could not be obtained by use of the method which short-circuits the motor terminals. Further, there was a disadvantage in that control was difficult to perform in the method which applies a reverse voltage to the motor. 30
- 35 Therefore, the above proposed video signal reproducing system is a highly desirable system in order to obtain a slow-motion picture in which there is little noise. However, in intermittently moving and stopping the magnetic tape, it is difficult to rapidly stop the rotation of the capstan motor. Hence, the realization of an apparatus capable of rapidly stopping the rotation of a motor was highly desirable in realizing the above proposed system. 35
- 40 Accordingly, a general object of the present invention is to provide a novel and useful apparatus for stopping rotation of a motor, which is capable of rapidly stopping the rotation of the motor. 40
- 45 The present invention provides an apparatus for stopping rotation of a motor comprising, a power source for supplying a driving voltage to a motor, reverse voltage applying means for alternately applying a reverse voltage to said motor and interrupting the application of said 45
- 50 50
- 55 55
- 60 60
- 65 65

reverse voltage, by applying the reverse voltage to said motor during a first predetermined interval upon stopping the rotation of said motor, and interrupting the application of the reverse voltage to said motor during a second predetermined interval which follows the first predetermined interval, and detection means for detecting the rotation of said motor during an interval in which the application of the reverse voltage to said motor is interrupted by said reverse voltage applying means, to stop the reverse voltage applying operation of said reverse voltage applying means when it is detected that the rotation of said motor has stopped.

Another and more specific object of the present invention is to provide an apparatus for stopping rotation of motor, constructed to stop the rotation of the motor by repeating operations in which a reverse voltage is applied to a rotating motor to apply rotation in a reverse direction to the rotating direction of the motor for a predetermined interval and then the application of the reverse voltage is interrupted for a specific interval, and a counter electromotive voltage of the motor is detected within the interval in which the reverse voltage is applied to the motor, until the detected counter electromotive voltage of the motor becomes zero or becomes of a polarity opposite to the above rotating motor. According to the apparatus of the present invention, the rotation of the motor can be stopped rapidly. Moreover, the motor is prevented from rotating in the reverse direction since information such as whether the rotation of the motor is stopped and the rotating direction of the motor are detected by detecting the counter electromotive voltage of the motor. By using a predetermined apparatus such as a micro-computer and a motor driving circuit, the rotation of the motor can be stopped positively with high reliability, and further, the size of the apparatus itself can be reduced. Particularly in a case where the apparatus of the present invention is applied to a capstan motor in a recording and or reproducing apparatus which performs slow-motion reproduction by intermittently moving a magnetic tape and stopping it accurately at a desired stopping position. In addition, since the magnetic tape can be stopped rapidly, a slow-motion reproduction can be realized in which instability of the picture, noise, and like are not introduced.

Other objects and features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

Figure 1 is a systematic block diagram showing a video signal slow-motion reproduction and still reproduction system applied with an embodiment of an apparatus for stopping rotation of a motor according to the present invention;

Figures 2(A) through 2(F) are diagrams respectively indicating the waveforms of signals at various parts of the block diagram shown in Fig. 1;

Figure 3 is a diagram indicating a track pattern at the time of recording;

Figure 4 is a diagram indicating the scanning track pattern at the time of still picture reproduction;

Figure 5 is a diagram showing the level of the reproduced signal at the time of still picture reproduction;

Figure 6 is a diagram for a description of position where the tape should be stopped at the time of still picture reproduction according to the system of the present invention;

Figure 7 is a systematic circuit diagram showing an embodiment of a concrete circuit construction of an essential part of the apparatus for stopping rotation of a motor according to the present invention; and

Figures 8(A) through 8(I) are diagrams respectively showing signal waveforms at various parts of the block system shown in Fig. 1 and the circuit system shown in Fig. 7.

Referring first to Fig. 1 a video signal to be recorded is introduced into the system shown through an input terminal 11 and is passed through a recording and reproducing circuit 12 and supplied to a pair of recording and reproducing video heads 13a and 13b and to a vertical synchronizing signal separation circuit 14. The video heads 13a and 13b have mutually opposite azimuths and mutually different track widths as described hereinafter and are mounted on diametrically opposite sides of a rotary drum 16 rotated at a rotational speed of 30 rps. by a drum motor 15. A magnetic tape 18 is wrapped obliquely around the rotary drum 16 and a stationary drum 17 and is driven to travel in the arrow direction X by a capstan 19 driven by a capstan motor 20 through a belt 21 and a flywheel 22, and a pinch roller 23. A video signal is recorded by the video heads 13a and 13b alternately along tracks on the tape 18, successively one field per track, the tracks being resultingly positioned contiguously to each other and obliquely relative to the longitudinal direction of the tape.

On the other hand, a vertical synchronizing signal a (Fig. 2(A)) of 60 Hz which has been separated from the video signal in the vertical synchronizing signal separation circuit 14 is supplied to a monostable multivibrator 24, where its frequency is halved to 30 Hz. The resulting output signal is supplied to a monostable multivibrator 25 for adjusting the phase of the signal and, at the same time, by way of a switch 26 with its moving contact connected to a contact point R in a recording mode to a control head 27, by which the signal is recorded as a control signal on the lower edge of the tape 18.

The resulting output signal of the monostable multivibrator 25 is supplied, by way of a switch

28 with its moving contact connected to a contact *R*, to a sampling and holding circuit 29.

The above mentioned rotary drum 16 is coaxially mounted on a rotating shaft 31, which is driven by the motor 15 and rotates together with the rotary drum 16. A pair of magnets 33a and 33b of opposite polarity are mounted on a rotating disc 32 fixed coaxially to the rotating shaft 31. Together with rotation of the rotary drum 16, pulses *b* of positive polarity and negative polarity as indicated in Fig. 2(B) are obtained alternately by a pickup head 34 and are supplied to a flip-flop 35. The resulting output *c* of the flip-flop 35 of the waveform indicated in Fig. 2(C) is supplied, by way of a switch 36 with its moving contact connected to a contact *R*, to a trapezoidal wave forming circuit 37 and formed into a trapezoidal wave signal, which is then supplied to the sampling and holding circuit 29.

The present embodiment is designed so that, when the output signal *c* of the flip-flop 35 is at its low level, the video head 13a scans the tape, and when the output signal *c* is at its high level, the other video head 13b scans the tape.

In the sampling and holding circuit 28, the trapezoidal wave signal is sampled in its inclined part by the sampling pulse and a slope part. Thus, the sampled pulse is held. The resulting output signal of the sampling and holding circuit 29 is supplied through a motor driving amplifier 30 to the motor 15 thereby to control the rotation thereof. The rotational phase of the motor 15 is so controlled that the sampling position on the trapezoidal wave in the sampling and holding circuit 29 will become a specific position, for example, the middle position of the inclined part of the trapezoidal wave signal.

According to the above described controlling operation, the video heads 13a and 13b are rotated with their rotational phase maintaining a specific relationship with the phase of the vertical synchronizing signal of the input video signal. Adjustment of this phase relationship is made by adjusting the time constant of the monostable multivibrator 25, which time constant is adjusted by a variable resistor 38.

On the other hand, as the capstan 19 rotates, a pickup head 39 detects the rotation of the capstan 19, in cooperation with magnets (not shown) mounted on the flywheel 22. The signal thus detected is supplied to a control device 55. The output of the control device 55 is applied to the motor 20 through a motor driving circuit 58, to control the rotation of the motor 20. Accordingly, the capstan 19 causes the magnetic tape 18 to travel at a constant speed such that it is shifted by an amount corresponding to one track pitch during the period of time when the video heads 13a and 13b rotate over one-half of the complete single rotation respectively.

At the time of normal reproduction, the moving contacts of the switches 26, 28, and 36 are respectively switched to their contact points *P*, and a switch 41 and a switch circuit 43 are held with their moving contacts being connected to the contact points *N*. The control head 27 reproduces control signal *d* with a waveform as indicated in Fig. 2(D) which is supplied through the switch 26 and an amplifier 44 to a monostable multivibrator 45 having a delay time *t*₁. The resulting output signal *e* of the monostable multivibrator 45 of a waveform as indicated in Fig. 2(E) is supplied through the switch 28 to the sampling and holding circuit 29. On the other hand, the output signal of the flip-flop 35 is phase inverted by a phase inverter 46, and is then supplied through the switch 36 to the trapezoidal wave forming circuit 37. From the trapezoidal wave forming circuit 37, is derived a trapezoidal wave signal *f* as indicated in Fig. 2(F), which is in the polarity opposite to that of the trapezoidal wave signal at the time of recording. The trapezoidal wave signal *f* is supplied to the sampling and holding circuit 29, where it is subjected to sampling by the above mentioned sampling signal *e* delayed by the time *t*₁. Responsive to the output signal of the sampling and holding circuit 29, the motor 15 is controlled its rotation.

The video signal picked up or reproduced by the video heads 13a and 13b passes the recording circuit 12, and is led out through a terminal 54.

Here, it is to be understood that, when the trapezoidal wave signal is used as a signal to be sampled also at the time of reproduction, which trapezoidal wave signal has the same waveform as that at the time of recording, the operation for advancing rotational phase encounter some limitation. For this reason, it is adapted so that, at the time of reproduction, the downwardly inclined part of the trapezoidal wave signal *f* which has been phase inverted is subjected to sampling by the rising part of the signal *e* delayed by the time *t*₁.

Since the gaps of the video heads 13a and 13b respectively have mutually opposite azimuths, no signal is reproduced due to azimuth losses is the case where the video heads 13b and 13a respectively scan the tracks recorded by the video heads 13a and 13b (i.e., where so-called reverse tracking is carried out). Then, at the time of normal reproduction, the rotational phase of the motor 15 is so controlled that the sampling signal *e* which has been formed by the monostable multivibrator 45 responsive to the pulses of positive polarity in every two fields from the control head 27, as described above, will sample the middle part of the slope of the trapezoidal wave signal *f* formed in correspondence with pulses of positive polarity from the control head 27. In this case, the pulses of positive polarity from the control head 27 are so set that they are generated in coincidence with the rotational position of, for example, the head

13a. For this reason, in a normal reproduction mode, the rotational phases of the video heads 13a and 13b are so controlled that these heads will always scan (positive tracking) the tracks recorded by these heads 13a and 13b respectively, and the above mentioned reverse tracking does not occur.

5 The video heads 13a and 13b, as shown in Fig. 3, respectively have gaps 60a and 60b inclined by an angle mutually in the opposite direction relative to the direction perpendicular to the scanning direction, that is, have azimuths of the angle α . These video heads 13a and 13b have respectively different track widths W1 and W2 and are so provided that their respective end faces 61a and 61b are at the same reference face of the rotary drum 16. In the present 10 embodiment of the invention, the width W1 is substantially equal to 1.5W2 through 1.6W2.

As indicated in Fig. 3, tracks t1, t2, t3 ... are in contiguous contact without gaps therebetween, whereby the tape utilization efficiency is high. Each track is recorded with a part of a video signal corresponding to substantially one field.

Here, the angle between the video heads 13a and 13b, and the magnets 33a and 33b, and 15 the time constant of the monostable multivibrator 25 for adjusting phase are so adjusted that a vertical synchronizing signal is positioned near an end of the track. A control signal is recorded at the lower lateral edges of the tape 18 along a control track 62 in the longitudinal direction of the tape.

Next, an operation at the time of a still picture reproduction will now be described in 20 conjunction with Fig. 4.

For still-picture reproduction, the travel of the magnetic tape 18 is stopped, while the video heads 13a and 13b are rotated at the rotating speed which is the same as that at the time of recording or normal reproduction.

Referring to Fig. 4, when the head 13b, for example, starts to trace from a position at which 25 it is straddling the tracks t6 and t7, it traces along the path indicated by bold full line and terminates its tracing at a position where it straddles the tracks t5 and t6. Since the tape 18 is stopped, the head 13a also, with its end face 61a tracing the same path as that of the end face 61b of the head 13b, starts to trace from a position where it straddles the tracks t6, t7, and t8 and ends its tracing at a position where it straddles the tracks t5, t6, and t7. Thereafter, the 30 above described tracing operation is repeated.

The heads 13b and 13a have a normal tracking relationship to the tracks t6 and t7, respectively. For this reason, the level of the signal reproduced by the heads 13b and 13a is as indicated in Fig. 5. Here, it will be supposed that the relative tracing positions of the heads 13a and 13b with respect to the tape are offset, for example, to the left from the states shown in the 35 figure. In this case, the reproducing level L1 at the time of starting of tracing of the track t6 by the head 13b increases, but the reproducing level L2 at the time of completion of tracing decreases. Furthermore, the reproducing period of the maximum level L3 of the head 13a with respect to the track t7 becomes short, and the proportions of the tracing of the track t5 at the time of completion of tracing with respect to the track t7 increases. For this reason, beat 40 interference is produced in the portion in the vicinity of the level L4. On the other hand, when the relative tracing positions of the tape of the heads 13a and 13b are offset to the right from the states shown in the figure, the reproducing level L1 decreases from the track t6 of the head 13b, and the signal to noise ratio at this reproducing portion deteriorates greatly. Therefore, the 45 most desirable state of the tracing path of the heads 13a and 13b relative to the tracks at the time of still picture reproduction is that indicated in Fig. 4.

Then, at the instant when the control signal is recorded by the head 27, recording of the tracks t2 (t4, t6, ...) by the video head 13b is started. Consequently, if the tape travel is arbitrarily stopped at a desired still picture reproducing instant while the magnetic tape 18 50 recorded in this manner is caused to travel and be reproduced, the stopping position of the tape relative to the video heads will be indefinite.

Thus, if the tape travel is stopped immediately at the instant when the control signal is reproduced, the head 13b assumes the state wherein it starts tracing from the track t6, for example, while the head 13a assumes the state wherein it starts tracing from tracks t6 and t7, as indicated in Fig. 6. In this case, while the reproducing level of the track t6 is a maximum at 55 the time of starting of tracing of the head 13b, it becomes almost zero at the time of completion of tracing, and the noise becomes very great. Furthermore, the reproduced signal from the tracks t7 and t5 gives rise to beats during a certain period after the start of tracing of the head 13a, and the quality of the reproduced picture deteriorates greatly.

In contrast, the optimum tracing positions relative to the tracks of the heads for carrying out 60 still picture reproduction, as is apparent from Fig. 4, are the positions where the end faces 61a and 61b of the heads 13a and 13b trace along the single-dot chain line in Fig. 6. Accordingly, the magnetic tape 18 is caused to move through a distance l_1 and then stop after the control signal has been detected, and the tape travel is stopped with the heads 13a and 13b at the positions where they can trace in the optimum tracing state indicated in Fig. 4, in which the 65 noise and beat generated are minimum.

Next, the operation of carrying out slow-motion reproduction through the application of the principle of this optimum still picture reproduction will be described.

When the control manipulation for slow-motion reproduction mode of operation is carried out, the switches 26, 28 and 36 in the system illustrated in Fig. 1 are connected to their respective contact points *P*, while a switch 53 is closed. Furthermore, the frequency dividing ratio of a frequency divider 51, which is supplied with the output of the flip-flop 35, is set in accordance with the slow-motion of the slow-motion reproduction. For example, for $\frac{1}{2}$ slow-motion reproduction, the frequency division ratio is set at $\frac{1}{2}$.

The output square wave signal *c* of the flip-flop 35 is supplied to the frequency divider 51 wherein the frequency of the signal is divided into $\frac{1}{2}$ the original frequency. Accordingly, an output signal *g* having a waveform indicated in Fig. 8(A) is supplied to a monostable multivibrator 52. The monostable multivibrator 52 produces an output signal *h* having a waveform indicated in Fig. 8(B), which rises in response to a rise in the signal from the frequency divider 51 and falls after a specific time T1 which is determined according to the time constant of the monostable multivibrator 52. The reason the above delay of the specific time T1 is required, is to match the timing in order to eliminate noise generated upon starting of the reproducing system by varying the time T1.

The output signal *h* of the monostable multivibrator 52 is supplied to a flip-flop 49 and the control device 55 which is constructed from a micro-computer, through the switch 53 which is in a closed state.

On the other hand, a control signal *i* reproduced by the control head 27 as indicated in Fig. 8(C) (which is the same as the signal *d* indicated in Fig. 2(D), however, in Fig. 8(C), the illustration of the negative polarity pulse is omitted) is supplied to a monostable multivibrator 47 through the switch 26 and the amplifier 44. Therefore, a signal *j* having a waveform as indicated in Fig. 8(D) is supplied to the flip-flop 49 and the control device 55. The above signal *j* rises in response to a rise in the positive polarity signal *i*, and falls after a specific delay time T2 which is determined according to the time constant of the monostable multivibrator 47. The delay time T2 is related to the time it takes for the capstan motor 20 to stop after the reproduced control signal *i* is detected. That is, the capstan motor 20 stops rotating after a time which is the total between the above delay time T2 and the inertial rotation time of the capstan motor 20. The delay time T2 can be varied by varying the time constant of the monostable multivibrator 47, that is, by varying the resistance of a variable resistor 48. Accordingly, the variable resistor 48 is so adjusted, and the delay time T2 of the monostable multivibrator 47 is so adjusted that the distance from the detection of the control signal to the point at which the magnetic tape 18 comes to a full stop becomes the above described desirable distance *l*₁, which was explained in conjunction with Fig. 6. As one example in actual practice, the distance *l*₁ is of the order of approximately 0.4 mm., and the delay time T2 is of the order of a number of milliseconds.

The flip-flop 49 produces an output signal *k* which, as indicated in Fig. 8(E), rises in response to a rise in the signal from the monostable multivibrator 52 and falls in response to a rise in the signal from the monostable multivibrator 47. As will be described hereinafter, the period in which the above signal *k* is of high level coincides with the period in which the capstan motor 20 rotates.

When the capstan motor 20 rotates, the capstan 19 unitarily rotates with the capstan motor 20. Accordingly, the magnetic tape 18 which is pinched between the capstan 19 and the pinch roller 23 is moved in the direction of the arrow *X* in Fig. 1. The direction towards which the capstan motor 20 is rotating in the above state, will hereinafter be referred to as the positive direction. The output signal *k* of the flip-flop 49 is supplied to a NOR-circuit 57, the motor driving circuit 58, and a detection circuit 66.

An embodiment showing a concrete circuit of the above motor driving circuit 58 and the peripheral circuits, is indicated in Fig. 7. A high-level signal is constantly produced from one output terminal of the control device 55, and applied to one terminal of an AND-circuit 56. On the other hand, a signal *n* having a waveform as indicated in Fig. 8(H), is produced from the other output terminal of the control device 55, and this signal *n* thus produced is applied to the NOR-circuit 57 and the detection circuit 66. The signal *n* is normally of low level, and comprises a train of pulses which is of high level for a predetermined pulse width T4 which is produced intermittently, after a predetermined time T3 indicated in Fig. 8(F) has passed from the time when the output pulse *j* of the monostable multivibrator 47 which is applied to the control device 55 rises. The signal *n* is reset in response to a fall in a signal *o* indicated in Fig. 8(I) which is supplied from the detection circuit 66, and becomes of low level.

During the high-level period of the output signal *k* of the flip-flop 49 from time *t*_a to time *t*_b, the signal *n* obtained through the other output terminal of the control device 55 is of low level as indicated in Fig. 8(H). Accordingly, the output of the two-input NOR-circuit 57 to which the signals *n* and *k* are respectively applied, becomes of low level. This low-level output of the NOR-circuit 57 is applied to an input terminal 64a of a logic circuit 64 within the motor driving

circuit 58. On the other hand, the detection circuit 66 is constructed from a micro-computer, and supplies the signal ϕ indicated in Fig. 8(I) which rises in response to a rise in the output signal k of the flip-flop 49, to the control device 55 and the AND-circuit 56. Therefore, the output of the AND-circuit 56 becomes of high level during the above high-level period of the signal k (from time t_a to t_b). This high-level output of the AND-circuit 56 is applied to an input terminal 64b of the logic circuit 64. Furthermore, another input terminal 64c of the logic circuit 64 is connected to the output terminal of the flip-flop 49, and the high-level signal k is applied to this input terminal 64c.

As indicated in Fig. 7, the above logic circuit 64 comprises a two-input NOR-circuit 59 whose input terminals are respectively connected to the input terminals 64a and 64c, a two-input NOR-circuit 60 whose input terminals are respectively connected to the input terminal 64c and the output terminal of the NOR-circuit 59, a two input NOR-circuit 61 whose input terminals are respectively connected to the input terminal 64a and the output terminal of the NOR-circuit 59, and two-input NAND-circuits 62 and 63 whose input terminals are respectively connected to the output terminal of the NOR-circuit 61 and the input terminal 64b. Outputs of the NOR-circuit 60, NAND-circuits 62 and 63, and the NOR-circuit 61 are respectively obtained through output terminals 64d, 64e, 64f, and 64g of the logic circuit 64.

Each of the outputs obtained through the above output terminals 64d, 64e, 64f, and 64g are respectively applied to electronic switches S4, S1, S3, and S2 which are constructed from bi-polar or uni-polar transistors, as switching signals. The switches S1 and S3 are closed in response to a low-level switching signal, while the switches S2 and S4 are closed in response to a high-level switching signal. A series circuit comprising the switches S1 and S2 and a series circuit comprising the switches S3 and S4 are respectively connected between a power source 67 and ground. In addition, a connection point between the switches S1 and S2 is connected to one terminal of the capstan motor 20, and a connection point between the switches S3 and S4 is connected to the other terminal of the capstan motor 20. That is, the switches S1 through S4 construct a bridge circuit. Moreover, both terminals of the capstan motor 20 are respectively connected to input terminals of a comparator 65 comprising an operational amplifier.

The relationships between the levels of signals at the input terminals 64a through 64c and output terminals 64d through 64g of the above logic circuit 64 and the state of the switches S1 through S4 are respectively indicated in the following table. In the table, "H" and "L" respectively indicate high level and low level of a signal, and CL indicates that the switch is closed. Furthermore, the spaces left blank indicates that the switch is in an open state.

Table

	INPUT TERMINAL			OUTPUT TERMINAL				SWITCH			
	64a	64b	64c	64d	64e	64f	64g	S1	S2	S3	S4
(i)	H	H	H	L	H	H	L				
(ii)	H	L	H	L	H	H	L				
(iii)	L	H	H	L	H	L	H		CL	CL	
(iv)	L	L	H	L	H	H	H		CL		
(v)	H	H	L	H	L	H	L	CL			CL
(vi)	H	L	L	H	H	H	L				CL
(vii)	L	H	L	L	H	H	L				
(viii)	L	L	L	L	H	H	L				

Accordingly, in the high-level period of the output signal k of the flip-flop 49, from the time t_a to time t_b , the levels of the signals introduced to the input terminals 64a, 64b, and 64c of the logic circuit 64 are "L", "H", and "H", respectively. Hence, from (iii) of the above table, signals respectively having levels "L", "H", "L", and "H" are obtained through the output terminals 64d, 64e, 64f, and 64g of the logic circuit 64. Therefore, the switches S2 and S3 are closed and the switches S1 and S4 are opened. During the above period between times t_a and t_b , the current from the power source 67 accordingly flows through the switch S3, the capstan motor 20, and the switch S2, to rotate the capstan motor 20 in the positive direction.

The output voltage of the power source 67 is of a relatively high value at the time t_a , and has a waveform which gradually decreases towards the time t_b . Thus, during the above period between times t_a and t_b , a sloping wave voltage V such as that indicated in Fig. 8(F) is applied to the terminal of the capstan motor 20. This kind of a sloping wave voltage is used in order to obtain a rapid rise upon starting of the motor and minimize the stopping time required to stop the motor. The above sloping wave is obtained by use of a discharging voltage waveform of a capacitor.

Next, the output signal k of the flip-flop 49 falls at the time t_b . When the output signal k becomes of low level, the low-level signal k is applied to the input terminals 64c, and a high-level signal is applied to the input terminal 64a of the logic circuit 64. On the other hand, a high-level signal is continuously applied to the input terminal 64b of the logic circuit 64.

5 Accordingly, the output levels at the output terminals 64d through 64g respectively become "H", "L", "H", and "L" as indicated by (v) in the above table. Hence, the switches S1 and S4 respectively are closed, and the switches S2 and S3 are opened. The current from the power source 67 thus flows through the switch S1, the capstan motor 20, and the switch S4, to apply a reverse voltage to the capstan motor 20 so as to rotate the capstan motor 20 in a direction opposite to the direction towards which the capstan motor 20 had been rotating.

10 As described above, the control device 55 is set in response to a fall in the output pulse j of the monostable multivibrator 47, to supply the signal n indicated in Fig. 8(H) to the NOR-circuit 57 and the detection circuit 66. The signal n becomes of high level during the short time T_4 after the time T_3 has passed from the time t_b . Accordingly, the input level at the input terminal 64a of the logic circuit 64 changes to low level during the above short high-level period of the signal n . At this point, the levels at the other input terminals 64b and 64c remain at high level and low level, respectively. Therefore, during this short time period T_4 , the output levels at the output terminals 64d through 64g of the logic circuit 64 respectively become of low, high, high, and low levels, as indicated by (vii) in the above table. All the switches S1 through S4 are accordingly opened, and the supply of the reverse voltage to the capstan motor 20 is interrupted.

20 During the above time period T_4 , the capstan motor 20 continues to rotate in the positive direction due to inertia acting towards the positive rotating direction, although the reverse voltage is applied to the capstan motor 20 for the above predetermined time T_3 . Accordingly, a counter electromotive voltage respective of the rotation due to inertia in the positive rotating direction, can be detected from the terminals of the capstan motor 20. This counter electromotive voltage is detected in order to discriminate whether the capstan motor 20 is rotating according to the existence or non-existence of the counter electromotive voltage. Detection is alternately performed repeatedly for a predetermined interval to detect the application of the reverse voltage and the generation of the counter electromotive voltage, as will be described hereinafter.

30 The input terminals of the comparator 65 are respectively connected to the terminals of the capstan motor 20, however, since the input resistance of the comparator 65 is large, no undesirable effects are introduced in the capstan motor 20. The comparator 65 produces a high-level signal when the motor terminal voltage at the side of the switch S3 is higher than that at the side of the switch S1. On the other hand, when the motor terminal voltage at the side of the switch S3 is lower than that at the side of the switch S1, the comparator 65 produces a low-level signal. The comparator 65 is constructed to produce a low-level signal even when the counter electromotive voltage of the capstan motor 20 is zero. Therefore, during the period between the times t_a and t_b , a voltage is applied to rotate the capstan motor 20 in the positive direction. Hence, the comparator 65 produces a high-level signal m indicated in Fig. 8(G), and supplies the signal thus produced to the detection circuit 66.

40 The above detection circuit 66 rises in response to a rise in the output pulse k of the flip-flop 49. Further, this detection circuit 66 is put into a set state in response to a fall in the pulse k . In a case where the levels of the output signal n of the control device 55 and the output of the comparator 65 are of the same logical level (that is, when both are of low levels or high levels), the detection circuit 66 produces a high-level signal. On the other hand, when the levels of the signal n and the output of the comparator 65 are of different logical levels (that is, one is of low level and the other is of high level), the detection circuit 66 produces a low-level signal.

50 Moreover, the detection circuit 66 maintains the low-level output until the pulse k rises again.

The detection circuit 66 having the above described construction produces a high-level signal o as indicated in Fig. 8(I), during the above time interval between times t_a and t_b in which a voltage is applied to the capstan motor 20 to rotate the capstan motor 20 in the positive direction. During a following time interval indicated by T_3 after the time t_b , the output level of the comparator 65 becomes of low level since the reverse voltage is applied to the capstan motor 20. Moreover, the signal n is also low level as indicated in Fig. 8(H) during this time interval T_3 . Accordingly, the output level of the detection circuit 66 remains at high level. During the short time interval T_4 after the above time interval T_3 has passed, the application of the reverse voltage to the capstan motor 20 is interrupted, and the counter electromotive voltage of the capstan motor 20 is detected. Hence, the output level of the comparator 65 becomes of high level. In addition, the signal n is also of high level during this time interval T_4 as indicated in Fig. 8(H), and thus, the output level of the detection circuit 66 continues to remain at high level.

65 Similarly, after the above time interval T_4 , intervals are alternately repeated in which the reverse voltage is applied to the capstan motor 20 and the application of the reverse voltage is

interrupted (indicated by time intervals T5 and T6) as indicated in Fig. 8(F), and a fourth interruption of the reverse voltage is performed at a time t_c . At this point in time, when it is assumed that the rotation of the capstan motor 20 has completely stopped, or on the verge of slightly rotating in the reverse direction, the output m of the comparator 65 becomes of low level as indicated in Fig. 8(G). On the other hand, the above signal n again becomes of high level. Accordingly, the output signal o of the detection circuit 66 becomes of low level at the time t_c as indicated in Fig 8(I), and this low level state of the output signal o is maintained until a following time t_d when the pulse k rises again.

Therefore, it can be discriminated that the capstan motor 20 is not rotating at the time t_c , at least in the positive direction. The output of the AND-circuit 56 becomes of low level due to the low-level output of the detection circuit 66. Furthermore, since the signal n is of high level, the output of the NOR-circuit 57 becomes of low level. Hence, the output levels at the output terminals 64d through 64g of the logic circuit 64 becomes as indicated by (viii) in the above table, that is, the levels at the output terminals 64d through 64g respectively become "L", "H", "H", and "L", and the switches S1, S2, S3, and S4 are opened. Thus, the application of the reverse voltage to the capstan motor 20 is interrupted. This interrupting operation is continuously performed until the time t_d when the pulse k rises. The state indicated by (vi) in the above table is obtained when the signal n then becomes of low level and the output of the NOR-circuit 57 becomes of high level. In this state, the application of the reverse voltage to the capstan motor 20 is still interrupted, since the switches S1 through S3 are opened.

Accordingly, as described above, the time required to stop the rotation of the capstan motor 20 is reduced by applying a reverse voltage to the capstan motor 20. Moreover, since operations are repeated to detect whether the capstan motor 20 is rotating or which direction the capstan motor 20 is rotating by interrupting the application of the reverse voltage, and a reverse voltage is again applied to the capstan motor 20 in a case where the rotation of the capstan motor 20 has not stopped, the capstan motor 20 does not rotate in the reverse direction. The time interval (T3) in which the reverse voltage is applied to the capstan motor 20 is set at approximately 6 ms., and the time intervals indicated by T4, T5, and T6 in which the application of the reverse voltage to the capstan motor 20 is interrupted are set approximately equal to 2 ms. It has been experimentally confirmed that the time required from the starting of the capstan motor 20 until the capstan motor 20 is stopped (the time interval from time t_a to t_c indicated in Fig. 8(F), for example) should be approximately within 60 ms, in order to perform a stable slow-motion reproduction. According to the present embodiment of the invention, it is possible to stop the rotation of the capstan motor 20 well within the above time of 60 ms.

The above embodiment of the invention is applied to a slow-motion reproduction system such as in a VTR. Accordingly, by repeatedly starting and stopping the rotation of the capstan motor 20 indicated in Fig. 1, a normal reproduction picture for a predetermined frame interval in which the tape travels and a still reproduction picture for a predetermined frame interval in which the tape is stopped, are alternately and repeatedly obtained, and thus, as a whole, a slow-motion reproduction picture is obtained.

Upon recording in the magnetic recording and reproducing apparatus indicated in Fig. 1, the switches 26, 28, and 36 are respectively changed over and connected at the respective contact points P . Accordingly, the incoming video signal and the like to the input terminal 11 is recorded by the video heads 13a and 13b. Hence, the output signal of the monostable multivibrator 24 is recorded as a control signal by the control head 27, and the output signal of the monostable multivibrator 25 is supplied to the sampling and holding circuit 29 as a sampling signal. However, since these operations are not directly related to the subject matter of the present invention, detailed description thereof will be omitted.

A pulse having a repetition frequency respective of the rotational speed of the capstan motor 20, is applied to the control device 55, due to the flywheel 22 alternately provided with magnets of S-pole and N-pole at the peripheral surface thereof, and the pickup head 39, which are fixed at one end of the rotary shaft of the capstan motor 20. However, this pulse is only used in a operational mode in which the capstan motor 20 is rotated at a constant speed.

In addition, the present invention can be applied widely to stop the rotation of a motor, other than the above embodiment of the invention in which the rotation of the capstan motor 20 is started and stopped to obtain a slow-motion reproduction picture.

Further, this invention is not limited to these embodiments but various variations and modifications may be made without departing from the scope of the invention.

60 CLAIMS

1. An apparatus for stopping rotation of a motor comprising:

a power source for supplying a driving voltage to a motor;

reverse voltage applying means for alternately applying a reverse voltage to said motor and

interrupting the application of said reverse voltage, by applying the reverse voltage to said motor

during a first predetermined interval upon stopping the rotation of said motor, and interrupting

the application of the reverse voltage to said motor during a second predetermined interval which follows the first predetermined interval; and

5 detection means for detecting the rotation of said motor during an interval in which the application of the reverse voltage to said motor is interrupted by said reverse voltage applying means, to stop the reverse voltage applying operation of said reverse voltage applying means 5 when it is detected that the rotation of said motor has stopped.

2. An apparatus for stopping rotation of a motor as claimed in claim 1 in which said detection means has means for detecting a counter electromotive voltage generated upon rotation of said motor.

10 3. An apparatus for stopping rotation of a motor as claimed in claim 1 in which said power source generates a sloping voltage which is of high voltage upon starting of said motor and then gradually decreases. 10

4. An apparatus for stopping rotation of a motor as claimed in claim 1 in which said reverse voltage applying means has a control device for generating a train of pulses having a pulse 15 width equal to said second predetermined interval, with a period which is equal to a total period between said first and second predetermined intervals, and a motor driving circuit for changing 15 over the connection between said power source and said motor according to the train of output pulses of said control device upon rotation of said motor, so as to rotate said motor in a direction opposite to the direction towards which said motor had been rotating.

20 5. An apparatus for stopping rotation of a motor as claimed in claim 4 in which said motor driving circuit has four electronic switches respectively constructing each side of a bridge, said 20 bridge being connected with terminals of said motor at respective opposing apexes thereof, and a logic circuit for controlling the open or closed state of each of said electronic switches according to the train of output pulses of said control device.